SPATIAL CORRELATION BETWEEN INTERFEROMETRIC STACKING PATTERN DEFORMATION AND DAMAGE DISTRIBUTION OF ATHENS 7-9-99 EARTHQUAKE AND ITS SEISMIC SEQUENCE

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ABSTRACT:

The study presents an attempt to correlate the spatial distribution of damages and the ground deformation measure by SAR interferometric stacking technique in the case of Athens 7-9-99 earthquake. Damage maps were created for building collapsed and affected areas, built in a GIS environment. The location of the collapsed building was identified using a portable GPS resever and introduced as point thematic map in the GIS. The interferometric images show a clear deformation pattern of fringes mainly in the Thriassio Pedion basin as well as in Athens basin. Comparing the damage maps with the pattern deformation of the interferometric image in the GIS it appears that there in not a clear correlation between the amplitude of deformation and the observed damages. Other parameters seems to affect the distribution of damages the most importannt of which should be the local geological conditions and the vulnerability of the buildings .

1. INTRODUCTION

Athens basin constitutes the most populated basin of Greece with the cities of Athens and Pireaus. It was considered as having low seismic hazard (Figure 1). A magnitude Ms=5.9 earthquake hit Athens and the broader area on September 7, 1999, killing 143 people and causing considerable damages. The epicenter of the seismic event was located at the southwestern flank of Mount Parnitha in the Thriassio Pedio (Papadimitriou et al., 2002; Papadopoulos et al., 2000; Lekkas, 2001; Stavrakakis et al., 2002; Voulgaris, 1999). The main seismic event was followed by an intense after shock activity. A total of thirty one buildings totally collapsed, hundreds were severely damaged and more than 70.000 people became homeless. The damage to lifelines was insignificant, while no major ground failures (liquefactions, slope failures, etc.) were triggered by the earthquake (Bouckouvalas & Kourtezis, 2001). The majority of the damages were localized in the northern and western part of the Athens Basin. In these locations the macroseismic intensity was as high as IX degrees on the modified Mercalli-Sieberg scale, with a local maximum of IX+ degrees (Papanastasiou et al., 2000). According to (Marinos et al., 1999). The severe and heavy damages were concentrated in the areas of Ano Liossa, Axarnai and Thrakomakedones at a distance of 6 to 12 km from the epicenter. In some cases heavy damage was observed in scaterred areas far away from the epicenter. According to (Lekkas, 2001), the intensity distribution shows a complicated

geographic variability and arrangement both on macro and microscale and the parametters that control the damage distribution were alpine and post-alpine macrostructure, the characteristics of the seismic source, the seismogenic fault and the soil seismic response in specific areas. The aim of this study is to investigate spatial correlation between the co- and post-seismic ground deformation (determined by applying the interferometric stacking technique), and the damage distribution in the broader area of Athens caused by the seismic event of September 1999, using a GIS environment.

2. DATA PROCESSING

In the frame of the present study a GPS receiver was used to determine the precise position of each collapsed building according to the catalogue of the collapsed buildings provided by the Earthquake Planning and Protection Organization of Greece (EPPO). A point vector damage map was created. Additionally, a damage distribution map, which was created by the National Technical University of Athens (Strozzi et al., 2001), was used to recreate a vector damage thematic map taken in consideration only the areas with moderate, serious and very serious damages. A georeferenced high resolution satellite image (IRS-C Pan with resolution 5m/pixel), covering the entire area was used as geographical background in the GIS system. The two damage data sets were plotted on the Pan image and the accuracy of the

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points (collapsed buildings) and of the polygons (damage areas) was checked.

The ground deformation was measured using the interferometric stacking technique (Strozzi et al., 2001; Raucoules et al., 2003a; Raucoules et al., 2003b). Stacking differential interferograms involves summing multiple differential interferograms into a single interferogram. This is useful to overcome two shortcomings of conventional InSAR: (i) low coherence over long temporal separations. If reasonable coherence levels can only be obtained over short time periods (for example in the case of rural settings in temperate climates), then several short time
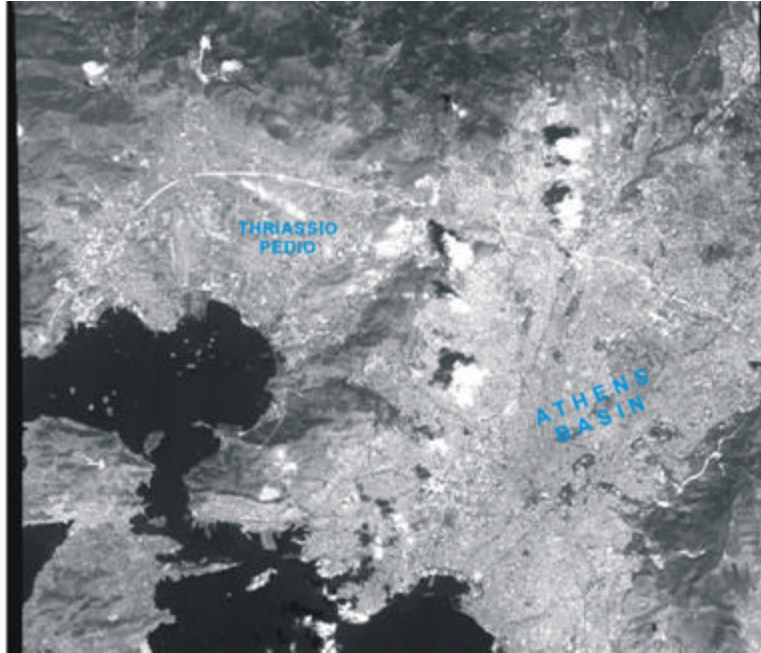
Figure 1 IRS Panchromatic image showing the broader area of Athens. On the left the Thriassio Pedio basin and on the right the Athens basin are shown.
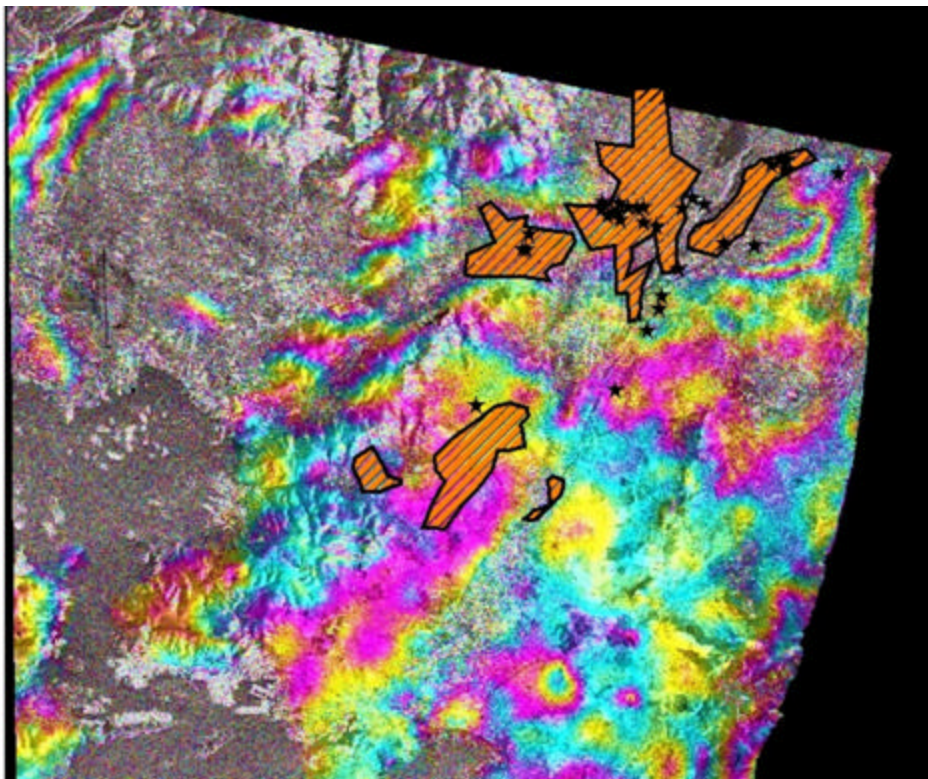

Figure 2 Interferometric image overlapped by the areas of severe damages (polygons) and location of collapsed buildings (points).

period, temporally contiguous interferograms can be summed (subject to data availability) to produce a pseudo interferogram over a longer period.This enables low magnitude displacements to be monitored over longer periods, where no single coherent interferogram exists, (ii) atmospheric influence. When multiple differential interferograms exist bracketing an instantaneous event (such as an earthquake or other sudden ground displacement) they can be summed to increase the (displacement) signal to (atmospheric) noise ratio. This is possible because the displacement signal is constant in each interferogram whereas the atmospheric signal varies randomly.

We acquired a set of 55 ERS-1/2 images covering the area of the city of Athens between 1992 and 2002 in order to detect ground deformation (Lagios et al., 2004). A number of 264 interferograms have been produced using an automated procedure based on the Gamma interferometric software and the IDL software. Between these interferograms, we have selected a set of 60 pairs for their quality in terms of coherence and signal to noise ratio. In addition, the interferograms were filtered using an adaptive filter to reduce their noise. In the framework of this study, we focused on the September 7 1999 earthquake signature (ground deformation related to water pumping has also been detected).

Two interferograms have been summed: the pair 1993-05-03 / 2000-11-16 and the interferometric pair 1996-10-03 / 2002-07-04.

3. CONCLUSIONS - DISCUSSION

A number of interferometric fringes are recognized in Thriassion Pedion basin of semicircular shape opened to the north. The above fringes are clearly evident mainly at the borders of the basin, as the its inner part is partly characterized by agricultural fields and natural vegetated areas, reducing the coherence.

In Athens basin interforemetric fringes are located in its northern part showing a E-W elongation. In the same area and specifically at the northeastern part two semicircular fringes are related to water pumping (Lagios et al., 2004).

We correlated the gradient of the fringes with the thematic maps of collapsed buildings and areas of severe damages distribution (Figure 2). There is no high spatial correlation between the damages and pattern deformation. In the Thriassion basin where the epicenter of the main seismic event and the majority of the seismic sequence events are located, only minor damages are found while a number of interferometric fringes are recognized in the interferometric image. A correlation between damages distribution and the deformation measured by InSAR is observed in the northern part Athens Basin.

The above fact comes into contradiction with the deformation pattern as it is shown in the interferometric image, where the maximum deformation is observed in the area of Thriassion Pedion. Thus, the damages in the Athens basin could be basically attributed to the local geological conditions and to the failure of structures.

Concluding, the monitor of ground deformation, due to earthquake, in an urban area could provide useful information to that should be taken into consideration during the reconstruction of the area.

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